SCIENCE AND LIFE

ROBERT ANDREWS MILLIKAN

200

Herbert W Mason
4 Norman Road
Upper Montclair
New Jersey

LIBRARY
NORTHEASTERN BIBLE COLLEGE
ESSEX FELLS, N. J. 07021

SCIENCE AND LIFE

ROBERT ANDREWS MILLIKAN

215
M6215

SCIENCE AND LIFE

BY

ROBERT ANDREWS MILLIKAN, PH.D., SC.D., LL.D.

Director of the Norman Bridge Laboratory of Physics, California Institute of Technology. Awarded the Nobel Prize in Physics of the Swedish Academy of Sciences, 1923, the Edison Medal of the A. I. E. E., 1923, the Hughes Medal of the Royal Society of Great Britain, 1924, the Faraday Medal of the London Chemical Society, 1924

THE PILGRIM PRESS

BOSTON CHICAGO

THE MASTER'S COLLEGE
POWELL LIBRARY
SANTA CLARITA, CA 91321

Copyright, 1924
By SIDNEY A. WESTON

Printed in the United States of America

THE JORDAN & MORE PRESS
BOSTON

PREFACE

The following pages contain the points of view of an individual scientist upon some of the great problems of life which lie outside the field in which he can claim to speak with any sort of authority. Whether their publication can serve any useful purpose the reader must determine.

ROBERT ANDREWS MILLIKAN

Norman Bridge Laboratory of Physics
California Institute
Pasadena, California
May 3, 1924

CONTENTS

PAGE

I

THE PRACTICAL VALUE OF PURE SCIENCE 1

II

THE SIGNIFICANCE OF RADIUM . . . 13

III

SCIENCE AND RELIGION 38

IV

SCIENCE AND SOCIETY 65

I

The Practical Value of Pure Science[1]

WHEN I reflect that preceding Edison medallists have been men of the type of Charles F. Brush, who first showed the world how electricity might be used for city lighting; Alexander Graham Bell, whose invention was at the base of the whole vast system of modern communications; Frank Sprague, who had been responsible for the application of electric power to railway transportation; M. I. Pupin, who made long distance telephony possible; J. J. Carty, under whose inspiration and leadership the telephone repeater and amplifier, with all that they mean to the enrichment of modern life, have been brought forth, and others of like achievement in the application of electricity to large industrial uses, I feel that there may have been a misunderstanding or a mistake in con-

[1] Response to the presentation of the Edison Medal at Del Monte on the evening of October 4, when the president's presentation address was made by Dr. Frank B. Jewett from his home in New Jersey, his voice being carried over telephone lines and amplified through the magnivox so as to be very distinctly audible to the entire audience seated at dinner in the Del Monte Hotel, three thousand miles away.

nection with this year's award. For when I look over my thirty years of scientific effort I can find no industry which has grown out of my researches, nor even any which have been very immediately benefited by them.

Since then this survey reveals nothing of great industrial consequence I am obliged to adopt either the mistake-theory, or, as an alternative, to assume that the American Institute of Electrical Engineers has this year been led to adopt a new policy — a policy of recognizing occasionally, at least, as something of vital, practical importance to the world, a type of activity which does not lead to immediate industrial advances. I am going to assume that this last hypothesis is correct, and in behalf of all workers in what is called the field of pure science, all those who are spending their lives in trying merely to ferret out nature's secrets and to better man's understanding of her laws, I wish not only to express my appreciation to the Institute for the award, but also to compliment it upon the breadth of its own vision and the service to science which it has done in recognizing before the public the value of this other field. For, in the final analysis, the thing in this world which is of most supreme importance, indeed the thing which is of most *practical* value to the race, is not, after all, useful dis-

covery or invention, but that which lies far back of them, namely, " the way men think " — the kind of conceptions which they have about the world in which they live and their own relations to it. It is this expanding of the mind of man, this clarifying of his conceptions through the discovery of truth which is the immediate object of all studies in the field of pure science. Behind that object, however, is the conviction that human life will ultimately be enriched by every increase in man's knowledge of the way in which nature works, since obviously the first step in the beneficent control of nature is a thorough understanding of her.

To illustrate my contention that the way men think is the most important and the most practical thing in human progress, I wish to consider briefly two great epochs in history in which significant changes have been brought about in man's conception of his world and of the place he occupies in it. The first epoch began just four hundred and fifty years ago; for this year happens to be the four hundred fiftieth anniversary of the birth of Copernicus, or, as he was known in his native Poland, Nikolaus Copernik, a man who spent his life not primarily in the pursuit of astronomy, but rather in the service of the church, for he was Canon of the Cathedral of

Frauenberg. More than any other this man was responsible for changing the conceptions of mankind about the things which some men who call themselves practical would say had no bearing upon this life of ours at all, and yet there was not a political or social change in Europe during the two or three succeeding centuries which it did not affect.

It is not strange that through all the ages up to the time of Copernicus the earth had been the center of man's universe, nor indeed that his whole thinking had been ego-centric — that he felt that the universe had been created especially for him with every bird and beast and flower ministering to his pleasure. Nor is it strange that in spite of this self-centered conception, surrounded as he was with mysterious forces, his philosophy of life had been a supinely fatalistic one, — that little idea had as yet entered his mind that he himself might have any real control over nature, or that he had any responsibility for the shaping of human destinies. In all the ancient world three blind fates sat down in dark and dank inferno and spun out the lives of men. Man himself was not a vital agent in the march of things; he was but a speck tossed hither and thither in the play of mysterious, titanic, uncontrollable forces. Even after the advent of Christianity no

idea of the possibility of changing bad conditions by human effort gained access to his thinking. The best that he could do was to withdraw from the world and to cultivate his soul in a monastery, or to mortify the flesh after the manner of the pillar-saints, in the hope of sometime getting into a better one.

Now note first the simplicity of the process by which a change in his thinking begins to come about, and then note the result. The simplicity of the process has been characteristic of the advance of science in all ages. Careful observations, such as men made in those days as well as this, had brought out difficulties in the explanations which had come down from the past. The dome of heaven rotating about the earth and carrying the fixed stars, and other transparent crystalline domes carrying the planets and the sun and rotating at different speeds, were simple enough if one was not too insistent upon the requirements of mechanical engineering, but careful observation had shown retrograde motions, at certain seasons, of the planets outside the earth's orbit, which were actually due to the fact that the earth itself was at these times speeding between these outer planets and the sun at an angular speed greater than their own, thus causing

them to seem to go backward. Such phenomena imposed impossible conditions upon the crystalline domes of the ancients unless the most complicated and grotesque assumptions were made. Copernicus wrote his only book to show that all these difficulties disappeared and all explanations came out far more simply if the earth was assumed to be but one of a number of little planets rotating once a day upon its axis and circling once a year about the sun. But realizing that this new conception might arouse opposition because it robbed man of his central position in the scheme of things he wrote to the Pope, to whom he dedicated his book, asking him to use his influence to defend him from those who might attack his theory "because of some passage of Scripture which they had falsely distorted for their own purposes." Here is a devoutly religious man four hundred years ago of sufficient vision to see, even in the dim light of that shadowy age, that the foundations of real religion are not laid where scientific discoveries of any kind can disturb them, and who therefore keeps his mind open at all times to truth from whatever angle it tries to enter.

But now look at the results of the introduction of this new way of thinking upon a subject which had apparently no industrial or

commercial bearings whatever. The shock to tradition and to established custom was too great for the unseeing of his day as it is of ours. The Inquisition came and the frightful religious wars of the next two centuries all because of the introduction of some new ideas into men's minds. Truly *the way men think* is the most practical concern in life, for all conduct flows from it!

But slowly the truth prevailed, and for four centuries the sciences of celestial mechanics and of Newtonian dynamics had greater and greater successes until it became impossible for even the most narrow visioned and unintelligent of men to doubt the fundamental correctness of Copernicus' ideas, even though they had been branded at their inception as impious and untrue by popes and emperors and scholars, even as enlightened a one as Luther, because they were " in direct contradiction to the Scriptures."

The second epoch of which I wish to speak is that in which we live; for it is quite as extraordinary as that of Copernicus in the rapidity with which new conceptions are being introduced and in the influence of these conceptions upon human life and conduct. Look at what has happened within my own lifetime in the field of physics, for example. When I started my graduate work in 1893 so

sure were we of the physical foundations of our world, with its seventy-odd, unchangeable, indestructible elements, its well-formulated laws of matter-physics and its equally firmly established laws of ether-physics, — ethereal and material phenomenon being sharply and definitely differentiable, — and the principles of the conservation of energy, the conservation of mass, and the conservation of momentum acting as nature's policemen to keep the universe running eternally within the law, that it was then being frequently said, often by the ablest of physicists, that it was probable that all the great discoveries in physics had already been made and that future progress was likely to arise only by increasing the refinement of our measurements. Then came, only two years thereafter, the capital discovery of X-rays, an entirely new phenomenon, having no relation whatever to refinements of measurement. And two years later came radioactivity, which has now completely exploded the notion of the eternal character of the atom and revealed a world in which many if not all of the so-called elements are continually undergoing change, spontaneously shooting off projectiles with stupendous speeds, speeds far beyond those which it had ever been thought possible that matter in any form could

attain. And then three years later came the beginnings of the quantum theory, which has shown us unmistakably (so it appears) that in the domain in which electrons live even the electro-magnetic laws no longer hold. And then a few years later, through Einstein's insight or speculations, as you prefer, mass and energy became interconvertible terms, and now we are all agreed that our former sharp distinctions between material, electrical and ethereal phenomenon have got to be abandoned. And, most important of all, from the amazing progress of physics has come more and more to the fore the idea that man has himself the ultimate ability to control for his own ends many of the changes going on in this changing world. How could it be otherwise when within a hundred years the very greatest of modern industries, that represented by the American Institute of Electrical Engineers, has been created through man's gaining year by year a larger and larger control of what used to be the most mysterious and apparently the most uncontrollable phenomenon of nature, the thunder-bolts of Jove.

And geology, too, is telling us the same kind of a story. It is but fifty years since the death of Lyell, a man who, more perhaps than any other, first taught us to read the story of the

rocks, yet now so well have we learned the lesson that, to use a single illustration, we count the exact number of years since the last ice age by the annual deposits on the shores of the Baltic Sea in just the same way as we obtain the age of a tree by the counting of its rings. And through all this expanding knowledge has come the definite evidence that man himself has been here perhaps five hundred thousand years, and yet that his extraordinary development, not physiologically, perhaps, but socially, has been exceedingly recent, much of it within a generation or two, since the developments in physics have given him control of the giant forces formerly wielded only by the Titans.

And the developments in biology taking place under our very eyes tell the same story. Bacteriology has already banished some of man's most dreaded scourges. In the fields of agriculture, horticulture and animal husbandry, man now builds plants and fruits, and even animals, almost to suit his taste. If he hasn't a drought-resisting wheat, a seedless orange or a grape he goes to work to make one. If he does not find an ox adapted to resist the Texas winds like a buffalo and to put on flesh like a Durham, he creates one. As a result, then, of the modern pursuit of pure science in all its branches — the follow-

ing of that inner urge simply to know, to explore, to understand, two new ideas completely foreign to the ancient world and to many races of the modern world as well have come into our western civilization. The one is the idea of the possibility of progress, of continuous development; and the other the idea of man's ability to control and in the Providence of God (and I say it in all reverence) to determine to a large extent his own destiny, the idea of his own responsibility for the kind of an external world in which he lives. And if you wish to see the practical result of this changing of "the way men think," look at the difference between our own civilization and the static civilizations of Asia, where Nirvana is the goal of human life and a large fraction of the population reaches it quickly through starvation. Why is it that "fifty years of Europe is better than a cycle of Cathay"? Is it not simply because in certain sections of the world, primarily those inhabited by the Nordic race, a certain set of ideas have got a start in men's minds, the ideas of *progress* and of *responsibility?*

And these ideas have come about, I think, because in a few sections of the earth men have been led to follow simply the urge to know. First, to know this earth geograph-

ically, to explore it clear to the north pole and to the south pole, even when they knew there was not the remotest prospect of growing wheat or potatoes there. But now the days of geographical exploration are gone, and yet it is the same urge which leads on the descendants of these voyagers into the unknown — the astronomer to explore the heavens, however useless that may be, the physicist to study the properties of matter and radiant energy whether he sees any immediate application for his results or not, the biologist to delve as far as he can into the secrets of life and of organic growth.

On behalf of all those who are working in the field of pure science, all those pioneers who are pushing out beyond the present frontiers of human knowledge — where a few years hence the engineer and the other builders of a future more perfect civilization than our own will follow them — on behalf of all those who are struggling on in this field, which does not often meet with large public appreciation, I extend my heartfelt thanks to the American Institute of Electrical Engineers for helping to educate the public up to its values by recognizing it with an occasional Edison award.

II

The Significance of Radium[1]

WE are met to-night to honor a discovery and the discoverer, and we are doing it in a way which I am sure delights her soul as much as it does mine. The custom of mankind, when it would do honor to one who has had the good fortune to be of service to his fellows, is to make a hundred thousand dollar parade, or to fire a hundred thousand dollar salute, or, in rare instances of sounder judgment, to build a hundred thousand dollar monument. Compare that sort of an expenditure of the fruits of human toil with the glad donation which you are making to-night of a hundred thousand dollars, not merely for the alleviation of suffering and the arrest of disease — that is important — but for something which is vastly more important and more fundamental than that, namely, for the purpose of making it possible to peer farther into the secrets of matter, for upon that vision and

[1] An address delivered at the National Museum, Washington, D. C., on the evening of May 25, 1921, in connection with the presentation of a gram of radium to Madame Curie. Reprinted from "Science," New Series, Vol. liv, No. 1383.

the control of nature which that vision must precede depends the weal or woe of our children and our children's children for countless generations.

I wish to add a second element of uniqueness to this occasion. Knowing Madame Curie, as I have had the good fortune to do, I am sure that she would not wish me to speak a word of fulsome praise or to picture her as a superman; she is that because she is a woman, but not because she has had the capacity and the good fortune to make discoveries of the first importance. It is a common and pathetic spectacle to see military, political, and social leaders who come conspicuously into the public gaze, lose their sense of perspective and begin to regard themselves as holding a commission from the Almighty. I have never known a great scientist to make that blunder. And there ought never to be one who makes it, because the business of science is to see things as they are. Madame Curie has always remained simple, modest and unaffected in the face of the world's applause. That is the highest compliment which a fellow scientist can pay her, and the surest sign that she is not an ordinary person. With that I have paid my tribute of respect and honor and admiration to the discoverer.

Now for the discovery. How did it come about? What is it? What is its significance immediate? What is its significance remote and far-reaching? In order to answer that series of questions I wish to begin by disabusing your minds of the idea, if they harbor it, that a discovery in science is an isolated event. A science grows in the main as does a planet by the process of infinitesimal accretion. Practically every experiment in physics is a modification of an experiment which has gone before. Almost every new theory is built like a great medieval cathedral, through the addition by many builders of many different elements, one adding a little here and another a little there so that to the eye of a distant observer in the clouds the whole structure seems to move forward in a practically continuous way. Even when you get close up and begin to see the discontinuities, for they are there, each experiment in the development of a given field of science is found to have a pedigree just as truly as has a race-horse. Man-o'-war did not develop his marvelous speed in one generation. A dozen sires and dams contributed to that result. In precisely the same way, when in 1896 Henri Becquerel, professor of physics in the University of Paris, discovered the new, extraordinary property which certain types of

matter were found to possess and which was named radio-activity, that discovery was sired by one made a year before by Roentgen, and Roentgen's was sired by Lenard's, and Lenard's by that of Hertz in 1886, and Hertz's by the work of Maxwell, and Maxwell's by that of Faraday in 1831, and Faraday's by that of Oersted in 1819, and Oersted's by Volta's, and Volta's by Franklin's, and so on without limit. And the point to which I wish to call your attention now is that it is of incalculable importance that there should be people like those who have given this gram of radium to Madame Curie who have a vision that extends, not to this generation only, but to the generations that are to come a hundred, two hundred years ahead, and who consciously set about starting such a train of scientific discovery and progress.

But for our present purpose I wish to break into this chain of scientific development at the discovery by Professor Becquerel of this extraordinary phenomenon of radio-activity made in the physical laboratory in which Madame Curie had been studying for some years. The discovery itself was really a simple thing, as are practically all great discoveries. The year before Roentgen had found his X-rays, as he called them, which had the peculiar property of making it possible

for one to see his own skeleton. That attracted the world's attention and Professor Becquerel was endeavoring to see whether rays that would penetrate in that fashion could be produced from other sources. He naturally took uranium, because of its fluorescent property to see whether it, under the action of light, might perhaps transmute the light waves into penetrating waves of the kind Roentgen had obtained. What did he find? He tried it in the light and he tried it in the dark, and he found that it was not necessary to have light at all, but that a bit of uranium put away in a black paper on top of a photograph plate, itself would blacken the plate. In other words, there was a property of self-activity in that uranium. It emitted rays of some kind which would affect a photographic plate and discharge an electroscope. The discharge of an electroscope, in popular language, is simply this: When you comb your hair on a cold winter day and it stands out in all directions, it is because it becomes electrically charged. If now a bit of radio-active substance is held above your head, your hair will fall down again; *i. e.*, your electroscope will be discharged. The laboratory electroscope is merely a gold-leaf which stands out like your hair when it is charged and collapses when it is discharged.

The electroscope then became the chief agent by which radio-activity could be tested, and Madame Curie with her husband — for she had been married the year before to Pierre Curie, professor of chemistry in the University of Paris — began the study of other substances than uranium to see how general this new property was, and they found that the two heaviest elements in nature, uranium and thorium alone of the then known elements, possessed it, but they also found that the natural ore of uranium — which we commonly call pitchblende, and which is more than fifty per cent. uranium oxide, although it contains many other minerals like barium and lead and bismuth — that this pitchblende discharged the electroscope approximately four times as fast as did pure uranium oxide. This meant, as the Curies at once interpreted it, that there must be some hidden elements in the pitchblende which had the same radio-active property as uranium but in larger degree. And so they began the search to see if they could not separate the element which was responsible for that activity, and after two or three years of arduous work Madame and Monsieur Curie were able to announce that by using the ordinary methods of chemical analysis, by making precipitates and testing the activity both of

the precipitate and filtrate to see with which the activity went and therefore what were the chemical properties of the substances that had it, they had been able definitely to discover the existence of these two new radio-active elements of which Dr. Walcott spoke. The first of these did not exist in sufficient amount so that it could be detected by any other properties than its activity. This was named polonium, in honor of the land in which Madame Curie was born, for her father was a professor in the Technische Hochschule at Warsaw. This polonium, by the way, has been one of our most useful agents in getting at the inner properties of the atom, because it has the power of emitting one type of ray alone and not a mixture of rays as does the other and more famous radio-active element which the Curies discovered. This other new element they named, appropriately, radium because it had a radio-activity a million times, weight for weight, that of the pitchblende, and three or four million times that of pure uranium.

This is the simple, unadorned tale of the discovery of radium, but I am sure you do not appreciate the kind of painstaking research and labor which that simple tale represents. You may perhaps get a little glimpse of what it means — of what a search for a needle in a

haystack it was — when I say that the amount of radium in uranium is one part in 3,200,000; or that, in order to get the little gram of radium which is being presented to Madame Curie to-day it was necessary to take 500 tons of Colorado carnotite ore, which possesses two per cent. of uranium and to treat it with 500 tons of chemicals, apart from water and coal. So that you see the problem of bringing to a successful issue that search was one that places Madame Curie and her husband in the front rank of the world's scientific men and women.

The Nobel prize for 1903 was awarded jointly to Henri Becquerel and Monsieur and Madame Curie for their studies in radio-activity, and in 1911 the Nobel prize was awarded to Madame Curie alone for isolating radium — getting it as a pure metal (in the early experiments it was a bromide or chloride) — and for determining its atomic weight, which comes at 226.0. The heaviest element, uranium, has an atomic weight of 238, so that this is only twelve units lower than that.

So much for the way in which the discovery came about. But what is radio-activity? Perhaps I can tell you in as few words as possible by this simple statement. This gram of radium which you are presenting to Madame Curie to-day is continuously shoot-

ing off per second 145,000 billion particles which we call alpha particles, and with speeds which reach the stupendous value of twelve thousand miles per second. Now, when you recall that the super-guns which bombarded Paris could not eject a projectile with a speed of more than about a mile per second, you see how feeble imitations of nature we have as yet been able to produce. No band of Mexican bandits running amuck on a Texas town can compare for a moment with a colony of radium atoms which perpetually bombard their neighbors with broadsides having muzzle velocities of 12,000 miles per second. Not only that; these atoms of radium have lighter ordnance also. They shoot off in addition each second 71,000 billion particles that are one eight-thousandth as heavy as these particles which I have called the alpha particles. (The alpha rays are essentially helium atoms.) If we call these alpha particles the 13-inch guns of the radium atoms, then we might say that they have also seventy-five millimeter guns which shoot off relatively light projectiles. These, however, have a speed which is more than ten times as great as that of the alpha particles. We call them beta rays. They are simply free negative electrons, endowed with a speed which is close to the speed of light, namely,

close to 186,000 miles per second. But even that is not all. There is still one other type of rays being given off by this gram of radium. These other rays are the wireless waves of the denizens of the sub-microscopic world. They are ether waves just like light or just like wireless waves, except that the vibration frequency — the number of oscillations per second which the electronic inhabitants of the atom send off — amounts to thirty billion billions per second. These are the so-called gamma rays.

Now as to penetrating powers. The alpha rays, or helium atoms, shoot right through the walls of a thin glass tube just as though there were no wall there at all, and that, in itself, has thrown new light on the structure of matter. It has shown us that the atom is itself an existence which is mostly empty space. It is like a miniature solar system through which it is entirely possible for a new satellite or planet to shoot without meeting anything. One of these alpha particles shoots on through hundreds of thousands of atoms before it is brought to rest. It goes through seven centimeters of air which is of the order of a third of a foot. That is as far as the heavy projectiles which are shot off from the radium atoms can go. The lighter ordnance shoots a hundred times as far and the gamma

rays are a hundred times more penetrating still. I have thought you would be interested in actually seeing for yourselves the effect of these rays. I shall show first the effect of the gamma rays because, being those that are used in therapeutics, they are the ones you are most likely to be interested in. The gamma rays are simply ether radiations of very short wave-length, and whenever they pass through the atoms of matter they have the extraordinary power of ejecting with great speed from these atoms the electrons which are contained within them. And when these electrons pass in turn through other atoms they knock new electrons out of these atoms and thus put many of them into a condition in which they can make new combinations more readily than when they are not thus "*ionized*," or "excited." Now there is little doubt that the therapeutic effects of radium are simply due to the fact that these "excited" atoms have been put into a condition to make new chemical unions; *i. e.*, to produce new substances which are destructive of the normal tissues as well as of the cells of the disease which it is desired to destroy. But in some instances, at least, the disease is more susceptible than are the normal cells, and consequently it becomes possible to arrest the growth of those disease cells. As a matter of

fact, so far as the therapeutic effects of radium are concerned, the doctors who are in charge of the radium institutes will all tell you that you must not regard radio-active treatment as a cure for cancer. The only cure for cancer — the only certain cure — is surgical. Nevertheless, the effects of radium rays are to retard the growth of the malignant tumors and therefore to prolong life, so that, even in the case of cancers which are not capable of being operated upon — deep-seated cancers — life can often be prolonged several years by radium treatment.

The medical specialists will also tell you that there are certain types of superficial tumors and skin diseases which can be permanently and effectively cured, so that this kind of treatment has already been of sufficient use in therapy so that all who are familiar with it are at one in believing that it is highly desirable to introduce in all large centers of population these radium and X-ray hospitals of the kind which exist in Boston, New York, Chicago, Buffalo, Los Angeles, and several other cities, and which Paris is now to have because of the gift which you are making to Madame Curie.

The electroscope which by looking at the inverted image upon the screen you now see discharging rapidly under the influence of the

gamma rays from the radium, is exposed only to the rays which have passed through more than a half inch of lead; for the radium is completely enclosed in lead walls of that thickness. This gives you some idea of the marvelous penetrating power of these gamma rays. I now wish to show you some of Dr. C. T. R. Wilson's photographs of the actual tracks of the alpha, beta and gamma rays through air. After seeing these straight line tracks of the alpha and beta rays you will not doubt that radium is actually shooting off big and little projectiles of the kind I told you about. The wiggly, snaky tracks due to the gamma and X-rays are perhaps even more interesting and enable you to visualize somewhat what goes on in your body when you are taking X-ray treatment. Can you now wonder that these rays tend to destroy the tissues and to produce burns?

Now a word as to the significance of this radio-active process. The therapeutic significance I have already referred to, but from my point of view the insight which radium gives into the nature of matter is of vastly more importance than any possible effects it has in the cure of disease or in the alleviation of pain. Twenty-five years ago if we had been told that any kind of matter possessed the property of throwing out projectiles with

THE MASTER'S COLLEGE
POWELL LIBRARY
SANTA CLARITA, CA 91321

these enormous speeds we would have said "impossible." But not only in the enormity of the speeds of these projectiles is radium astonishing and revolutionary. There is something sublime about its ceaseless, unaltering and apparently unalterable activity, its complete indifference to intense heat or to extreme cold, to electrical or to chemical treatment of any kind. It is a property of the atom itself which we cannot at present control in any way.

But the third effect of this discovery is more important still, for what does it show that matter is doing? These alpha particles which are being shot off are portions of the atom of uranium or of the atom of radium and the thing which is left after the ejection of the alpha particle from an atom of uranium is no longer uranium. Its chemical and physical properties have entirely changed. The uranium atom in shooting off one of these alpha particles is thereby transmuting itself into another element. When it has shot off three alpha particles it has transmuted itself into radium, and when it has shot off five more it has transmuted itself into lead. We have seen in the laboratory the growth of lead out of uranium, and have followed the whole chain of transmutation of elements through this radio-active process. This neces-

sitates a conception of the nature of matter which was absolutely foreign to our thinking in the nineteenth century, and it is revolutionary in its significance. It means that these " eternal " elements — this radium and this uranium which we have here — are not eternal at all. The average life of the atoms of this radium is just 2,500 years, and after that time the average atom will have disappeared as radium, and if the world's supply of radium has not then mostly disappeared it will be because new radium is being produced all the time out of uranium. But uranium is the heaviest element we know of, and what is happening to it? It, too, is disappearing. But whence came it? It is true that the average life of the uranium atom is approximately eight billion years, so that when you go back so far as that, you may be inclined to say that it doesn't make much difference to this particular Republican administration where it did come from. Ah, but wait! In your thinking you have been forced to admit, for the first time in history, not only the possibility but the fact of the growth and decay of the elements of matter. With radium and with uranium we do not see anything but the decay. And yet somewhere, somehow, it is almost certain that these elements must be continually forming. They

are probably being put together now somewhere in the laboratories of the stars. That is still something of a guess, it is true, and yet the spectra of the nebulæ show that they contain only the lighter elements. Can we ever learn to control the process? Why not? Only research can tell. What is it worth to try it? A million dollars? A hundred million? A billion? It would be worth that much if it failed, for you could count on more than that amount in by-products. And if it succeeded — a new world for man! But what have we got already through the discovery of radio-activity? An immensely stimulating new conception of the universe and of the way matter is behaving.

Next consider the significance of radium with respect to the question of the availability of energy. The amount of heat given off from one gram of radium in disintegrating into lead is 300,000 times as much as the amount of heat given off in the burning of one gram of coal. There is, then, in the radium a supply of sub-atomic energy, and this raises the question as to whether such energy exists locked up in other atoms and as to whether there is any possible way we can get it. Do not be too sanguine about it as far as radium is concerned, because if all the radium at present in the world were set to work, al-

though it is 300,000 times as potent as coal per gram in giving off energy, it would not suffice to keep the corner popcorn man's outfit going. It does not exist in sufficient quantity.

But what has its discovery done then in the field of energy? It has opened our eyes to the fact that certain kinds of matter certainly possess these stores of energy and it is almost a foregone conclusion that similar stores are also possessed by the atoms which we have not yet found to be changing — which are not radio-active. The astronomer has for years been completely puzzled to account for the enormous amounts of energy which the sun and stars emit. He has not been able to find its source. It is impossible that the sun is simply a hot body cooling off, because we have evidence that it has lived longer than it could have lived if that were the case. The astronomer has now, however, seized upon the facts of radio-activity and surmises that these sub-atomic energies may be the source of the sun's radiation. If so the supplies are not so limited as we thought.

Look now at another side of this same problem. I am thinking particularly of the work of Professor Joly and Lord Rayleigh, who have made measurements of the amount of radio-activity of the ordinary surface rocks.

Professor Joly has computed that if there are two parts of radio-active material for every million million parts of other matter throughout the whole volume of the earth, and this is considerably less than he has found on the average in the earth's crust, then this earth, instead of cooling off, is actually now heating up; so that in a hundred million years the temperature of its core will have risen through 1800 degrees centigrade. That is a temperature which will melt almost all of our ordinary substances. What does it mean? It means that the life history of our planet is perhaps not at all what we have heretofore thought that it was. It means that a planet that seems to be dead, as this our earth seems to be, may, a few eons hence, be a luminous body, and that it may go through periods of expansion when it radiates enormously, and then of contraction when it becomes like our present earth, a body which is a heat insulator and holds in its interior the energy given off by radio-active processes, until another period of luminosity ensues. What I am now pointing out is the growth in our conception of the world, the growth in the thoughts of men that has come out from these studies. Do not think that this is not of importance. When Galileo discovered the moons of Jupiter he was doing just about as useless a thing from

the standpoint of its immediate applicability to human relations as he could have found to do. And yet what did he actually accomplish? He started off the train of thought, the mode of attack upon physical problems which has made this industrial age what it is, and therein lies the tremendous significance of a discovery of the kind we are honoring to-night.

We are so close to this age in which we live that we do not see what it means; we do not see it in its relation to other centuries. And therefore I should like to take you up in an Einstein airplane that violates all the relations of space and time so that you may see with me a few spots in geography and in time. Suppose we sail first, in the present, to the banks of the Tigris or Euphrates and see a picture which Professor Breasted drew to my attention when he came back from a recent mission to the Near East. He pictured the inhabitants of that region tilling the ground with a crooked stick, bringing their hard-earned produce to the shores of the river, putting it on crude rafts which were made from the skins of goats and sheep, and paddling it laboriously across to the other side. Then he threw on the screen a photograph of an ancient Babylonian tablet which showed the inhabitants of that region four thousand

years ago doing exactly the same thing in exactly the same way. Four thousand years without a bit of progress — each generation simply following the last in living a miserable existence, reproducing its kind and then passing on. Leave that! It is a discouraging picture.

Fly over into India and see this! I heard last winter Mr. Sam Higginbottam describe the conditions prevailing in that land now, where, as he said, millions of men go out into the fields in the morning with only a handful of grain — all they have to eat for the day; work a long day in perpetual hunger and feel that they would be perfectly happy if they could get all they wanted of such raw grain to eat. What wonder that heaven for these men is Nirvana — the escape from existence!

Now fly over China. To do so you have only to look at the poster which hangs tonight in front of this museum. Millions starving to death in China unless they can get help from the western world! Discouraging pictures! What is wrong with the world? Fly back to this country and perhaps the following sights may suggest an answer. Circle above the Mississippi near New Orleans, and contrast what you see with the picture on the banks of the Tigris. See a

train on the Southern Pacific Road bearing five hundred tons of produce from Texas, pulled upon a great ferry without even uncoupling the engine. See it in fifteen minutes on the other side ready to distribute its huge load of foodstuffs raised with the aid of automatic planters, tractor-plows and steam threshers on the broad plains of the West, to the millions of inhabitants in the eastern half of our country. Or, again, fly over the biggest copper mine in the world which is near Salt Lake City and look at a mountain of two per cent. copper being shoveled away by great steam shovels with comparatively little human labor. See forty thousand tons a day of ore pulled in huge hundred-ton cars a few miles to the mill. Then see one of those huge cars elevated, wheels and all, with no apparent human assistance, sixty feet high, turned slowly over and made to dump its load of ore into the mighty mill where a great, senseless, iron Cyclops grinds it into powder. Then watch the unseen natural forces of cohesion and adhesion in the flotation process pick out the ore from the gangue, without human aid, though controlled by human brains, and thus produce from sources altogether unusable fifteen years ago, the cheapest copper which the world has ever seen, the copper with which you are now

harnessing new water power and building new electric railroads across the continent, with which famine is made an impossibility in any part of these United States.

Now, what is the most essential and most significant element of difference between the two pictures which you have seen, the one here, the other half way around the earth? In this country, where the giant forces of nature have been set at work, the cheapest paid laborer on a building or in a steel plant, or on a farm got, before the great war, and he is getting now, for eight or nine hours of labor, more than twenty times as much as does that man in India or in China, — not merely in money but in actual goods to be purchased with his money. In other words, the common, unskilled laboring man in America has more than twenty slaves, but they are senseless, iron slaves, each of the same effectiveness as a common Indian laborer, who are doing his work for him. Why? Because Galileo and a few men like him a few hundred years ago got the idea that it was important to study out how nature worked. It is that study which has resulted in this modern scientific and industrial age. And it is only in the regions of the earth where that idea has got started, namely, in Western Europe and in this country, where

the conditions under which the average man lives and works have been thus alleviated. Note that I say "have been" not "are to be." True, they may be immensely more improved than they are now. I can see little immediate, practical needs as well as you. But let us not yet alight from our airplane. When you look at what *has already been done* by the advance of modern science — by getting an idea into a few men's minds — you begin to see that, after all, the important thing in this world is not the immediately practicable; the important thing is the growth of the human mind, the development of a few big ideas. Other things come from that, and therein lies the far-reaching significance of the experiments with radium; they have opened our eyes to new possibilities; they have given us a new conception of the growth and decay of the elements, and of the possibility of the human control of these processes; they have revealed the existence of new sources of energy which some time we may hope to be able to tap, and with the aid of which we may perhaps enrich human life in as yet undreamed of measure.

The first step is to see whether it is possible, by any means at our control, to disintegrate atoms. And we have already found that we can do it, and radium has helped us to make

that discovery. But we have only begun on this type of work. Its possibilities are as yet unknown. But of this much we feel very certain, namely, that through suitable research the already known sources of energy such as water, sun and tides, can be utilized for the benefit of mankind to an enormously larger extent than is now the case.

From my point of view there are two things of supreme importance in this world, two ideas or beliefs upon which, in the last analysis, the weal or woe of the race depends, and I am not going to say that belief in the possibilities of scientific progress is the most important. *The most important thing in the world is a belief in the reality of moral and spiritual values.* It was because we lost that belief that the world war came, and if we do not now find a way to regain and to strengthen that belief, then science is of no value. But, on the other hand, it is also true that even with that belief there is little hope of progress except through its twin sister, only second in importance, namely, belief in the spirit and the method of Galileo, of Newton, of Faraday, and of the other great builders of this modern scientific age — this age of the understanding and the control of nature, upon which let us hope we are just entering. For while a starving man may indeed be supremely happy

it is certain that he cannot be happy very long. So long as man is a physical being, his spiritual and his physical well-being cannot be disentangled. No efforts toward social readjustments or toward the redistribution of wealth have one-tenth as large a chance of contributing to human well-being as have the efforts of the physicist, the chemist, and the biologist toward the better understanding and the better control of nature.

Finally the most significant thing about this evening is the way in which this contribution to further progress has been made: Not through a public grant — that is not the method through which the genius of Anglo-Saxon civilization has ever expressed itself, but rather through private initiative. A large group of public-spirited people, of their own free will, have decided that they wished to have a part in the development of a new chain of scientific discovery. It is that spirit and that method which has made America what it is, and it is in the spread of that sort of intelligence among one hundred million people that our future lies.

III

Science and Religion

IN speaking upon this theme I am clearly somewhat out of my normal orbit. Most of my life has been spent in experimental work in the physical laboratory, devoted to the study of pure science, and in all such work the first aim is to eliminate all unnecessary complexities, to get rid of all secondary disturbing causes, to reduce the study of a particular phenomenon to its simplest possible terms in order to get at fundamental underlying principles, so that when conclusions are drawn they are obvious and inevitable. The result of such a method has been to build up a certain body of knowledge in physics which is assented to by all intelligent men who take the trouble to study it. I do not mean by this that there are no controversies in physics, but rather that there has been produced a very considerable body of non-controversial material. At the risk of being uninteresting because of the fact that I deal only with the obvious, I shall attempt to keep in my accustomed orbit sufficiently to use the

same method in discussing the relations between science and religion, for I think that at least nine-tenths of the controversy which rages in this field is due to a confusion which arises from the failure to eliminate purely extraneous and incidental matters, or to simple misunderstanding of facts which have been quite definitely established, or are at least practically universally recognized by the well informed.

There seems to be at the present time a strange recrudescence of a point of view which is completely out of keeping with the developments of the age in which we live, a point of view which thoughtful leaders of both science and religion have in all ages realized never had any basis for existence. In the time of Galileo it is perhaps understandable, in view of the crudity of the sixteenth century, that certain misguided religious leaders should have imagined that the discovery of the earth's motions might tend to undermine in some way the basis of religion and who, therefore, attempted to suppress Galileo's teachings. Yet it is to me not a little surprising that men even of such opportunities as Galileo's persecutors could have got religion upon such an entirely false basis in their thinking as to make its fundamental verities, its very existence, dependent in any way upon

any scientific discovery. It is not a question of whether Galileo was right or wrong, whether the earth actually revolves about the sun or the sun about the earth. That is a scientific matter with which religion as such has nothing whatever to do, and which should not have given it the slightest concern. Science could be counted upon to take care of that. It is its business to doubt, and it always does so as long as there is any room left for uncertainty. That even those inquisitors were far behind their own times in supposing that there could be any real contradiction between religion, properly understood, and the findings of astronomers cannot perhaps be better demonstrated than by the following quotation from St. Augustine, who lived twelve hundred years earlier, about 400 A.D., and is probably recognized as the most influential authority, next to Jesus and St. Paul, of the early Christian church.

" It very often happens," says Augustine, in commenting upon the entire distinctness from his point of view of the two great lines of thought, the natural and spiritual, " that there is some question *as to the earth or the sky, or the other elements of this world* . . . respecting which one who is not a Christian has knowledge derived from most certain reasoning or observation: and it is very dis-

graceful and mischievous, and of all things to be carefully avoided, that a Christian, speaking of such matters as being according to the Christian scriptures, should be heard by an unbeliever talking such nonsense that the unbeliever, perceiving him to be as wide from the mark as east from west, can hardly restrain himself from laughing."

That this same controversy that Augustine thus saw nearly sixteen hundred years ago had no basis for existence, because it is outside the proper field of religion, but which nevertheless flared up so violently in Galileo's time, and then died out as men grew in intelligence, should have appeared again in as enlightened a country as America, in the year 1922, is one of the most amazing phenomena of our times. But it is not less amazing than it is deplorable, for the damage which well meaning but small visioned men can do to the cause of organized religion as represented in the Christian church through the introduction inside the organization of such a disintegrating influence is incalculably greater than any which could possibly be done by attacks from outside. Indeed, should the movement succeed the church would inevitably soon lose all its most vital elements and society would be obliged to develop some other agency to do the work

which the church was organized to do, which in the main it has always done, and which to a very large extent it now does, namely, the work of serving as the great dynamo for injecting into human society the sense of social responsibility, the spirit of altruism, of service, of brotherly love, of Christlikeness, and of eliminating as far as possible the spirit of greed and self-seeking.

But I am not going to place the whole blame for the existence of this situation upon misguided leaders of religion. The responsibility is a divided one, for science is just as often misrepresented as is religion by men of little vision, of no appreciation of its limitations, and of imperfect comprehension of the real rôle which it plays in human life — by men who lose sight of all spiritual values and therefore exert an influence upon youth which is unsettling, irreligious, and sometimes immoral. The two groups, the one in the religious field, the other in the scientific, are in reality very much alike. They represent essentially the same type of mind, or perhaps I should say, the same stage of intellectual development. Each interprets the Bible, for example, essentially literally, instead of historically, the one to support, the other to condemn. Both may be assumed to be sincere, but the one is wholly unacquainted with

science, while presuming to judge it; the other is in almost complete ignorance of what religion is, while scoffing at it. I am ready to admit that it is quite as much because of the existence of scientists of this type as of their counterparts in the field of religion that the fundamentalist controversy has flared up today, and it is high time for scientists to recognize their share of the responsibility and take such steps as they can to remove their share of the cause.

I do not suppose that anything which I may say will exert much influence upon the groups whose prejudices have already been aroused, and who are therefore not interested in an objective analysis of the situation, but I may perhaps hope that some of the youth whose minds have been confused by the controversy may profit somewhat from a restatement of what seem to me the perfectly obvious and indisputable facts.

The first fact which seems to me altogether obvious and undisputed by thoughtful men is that there is actually no conflict whatever between science and religion when each is correctly understood. The simplest and probably the most convincing proof of the truth of that statement is found in the testimony of the greatest minds who have been leaders in the field of science, upon the one hand,

and in the field of religion, upon the other. Suppose, for example, that we select the greatest names in the last two centuries of the history of British sciences, or, for that matter, of world science. Everyone would agree that the stars that shine brightest in that history, as one's glance sweeps down from 1650 to 1920, are found in the names of Newton, whose life centered about 1680; Faraday, living about 1830; Maxwell, 1870; Kelvin, 1890, and Lord Raleigh, who died in 1921. No more earnest seekers after truth, no intellects of more penetrating vision, can be found anywhere, at any time, than these, and yet every one of them has been a devout and professed follower of religion. It was Kelvin who first estimated the age of the earth at something like a hundred million years without seeing the least incompatibility, in spite of the first chapters of Genesis, between that scientific conclusion and his adherence to the church, of which he was a lifelong member and a constant attendant. Indeed, in 1887, when he was at the very height of his powers, he wrote: "I believe that the more thoroughly science is studied the further does it take us from anything comparable to atheism." Again in 1903, toward the end of his life, he wrote: "If you think strongly enough you will be forced by science to the belief in God,

which is the foundation of all religion. You will find it not antagonistic, but helpful, to religion." His biographer, Silvanus P. Thompson, says: "His faith was always of a very simple and childlike nature, undogmatic and untainted by sectarian bitterness. *It pained him to hear crudely atheistic views expressed by young men who had never known the deeper side of existence.*" Just as strong a case of the same sort can be made by turning to the biographies of any of the other men mentioned, and these were chosen, let it be remembered, not because they were religious men, but because they are universally recognized as the foremost of scientists. Indeed, I doubt if the world has ever produced in any field of endeavor men of more commanding intellects than two of them, Sir Isaac Newton and James Clerk-Maxwell.

If someone says that I am calling only on the testimony of physicists and of Englishmen, then listen to the man whom the French nation has repeatedly voted the foremost of all Frenchmen, and who is also easily the peer of any biologist who has ever lived anywhere, Louis Pasteur, of whom his biographer says, "Finally, let it be remembered that Pasteur was a deeply religious man." Over his tomb in the Institute Pasteur are inscribed these words of his: "Happy is he who carries a

God within him, an ideal of beauty to which he is obedient — an ideal of art, an ideal of science, an ideal of the fatherland, an ideal of the virtues of the Gospel."

Or, again, if I am accused of calling merely on the testimony of the past, on the thinking which preceded the advent of this new twentieth century in which we live, I can bring the evidence strictly up to date by asking you to name the dozen most outstanding scientists in America today and then showing you that the great majority of them will bear emphatic testimony, not only to the complete lack of antagonism between the fields of science and religion, but to their own fundamental religious convictions. One naturally begins with the man who occupies the most conspicuous scientific position in the United States, namely, the President of the National Academy of Sciences, who is at present both the head of the Smithsonian Institute of Washington and the president of the American Association for the Advancement of Science, Dr. Charles D. Walcott, one of the foremost of American students of the evolution of life in the early geologic ages. He is personally known to me to be a man of deep religious conviction and has recently written me asking that he be described for the purposes of this address, which he has seen, as "an

active church worker." The same is true of Henry Fairfield Osborn, the director of the American Museum of Natural History of New York, and one of the foremost exponents of evolution in the country. Another rival for eminence in this field is Edwin G. Conklin of Princeton, who in recently published articles has definitely shown himself a proponent of the religious interpretation of life. In the same category I know, also from direct correspondence, that I may place John C. Merriam, president of the Carnegie Institution of Washington and America's foremost paleontologist; Michael Pupin, the very first of our electrical experts who has "approved every word" of this address and recently delivered a better one at Columbia University on this same subject; John Coulter, dean of American botanists; A. A. and W. A. Noyes, foremost among our chemists; James R. Angell, president of Yale University, and eminent psychologist, with whom I have had an exchange of letters on this subject; James A. Breasted, our most eminent archeologist, who served with me for years on the board of trustees of a Chicago church, upon which also T. C. Chamberlin, dean of American geologists, was a constant attendant; Dr. C. G. Abbott, home secretary of the National Academy of Sciences, eminent

astronomer and active churchman; and so on through the list of a large number of the scientists of eminence in this country.

Turn now to the other side of the picture and ask what have been the views of the most outstanding and most inspired religious leaders upon the relations of science to religion, and you obtain altogether similar testimony. Was it not Jesus himself, who said, "You shall know the truth and the truth shall make you free"? There is not one syllable in all that he taught nor one idea which he introduced into human life which would justify one in arraying him on the side of those who would see antagonism between any scientific truth and the deepest of spiritual values. There were no creeds in Jesus' teaching, no verbal inspirations of any sort. Religion was to him a life of love and duty, the simple expression of the Golden Rule.

Turning next to great religious personalities since Jesus' day, I have already quoted Augustine to show how he warned against religious leaders of such narrow insight as to make religion a laughing-stock by the presentation of an antagonism which did not exist. John Wesley, the founder of the Methodist church, in the chapter of his Compendium of Natural Philosophy on "A General View of the Gradual Progression of

Beings," has a passage which speaks of " the ostrich with the feet of a goat which unites birds to quadrupeds," and then continues, " By what degrees does Nature raise herself to man? . . . How will she rectify this head that is always inclined toward earth? How change these paws into flexible arms? What method will she make use of to transform these crooked feet into skillful and supple hands? Or how will she widen and extend this contracted stomach? In what manner will she place the breasts and give them a roundness suitable to them? The ape is this rough draft of man, this rude sketch, an imperfect representation which nevertheless bears a resemblance to him, and is the last creature that serves to display the admirable progression of the works of God. . . . But mankind have their gradations as well as other productions of our globe. *There is a prodigious number of continued links between the most perfect man and the ape.*"[1] (Italics mine.) I am not here asserting that Wesley's point of view was correct. For our present purposes that is quite immaterial. But he

[1] The foregoing quotation is not in Wesley's own words, but from the words of Charles Bonnet, from whose work, " The Contemplation of Nature," Wesley quoted twelve chapters comprising more than 150 pages of his " Natural Philosophy." Wesley, however, clearly adopts the views of Bonnet as his own, and in earlier pages of the same volume, namely 181 and 182, makes very similar statements.

was a supreme religious leader and the quotation shows that he saw too clearly to allow his scientific thinking to be trammeled by any man-made religious dogmas.

Again, in our own time, there has been no more spiritual religious leader than Henry Drummond, whose most inspiring work was in showing the contribution of science to religion, and I think I might name practically all of the outstanding religious leaders now living and say that there is not one in ten of them who would not take his place beside Jesus and Augustine and Drummond and Beecher and Lyman Abbott and Fosdick and Soares and King and Brown and Burton and Mathews and a host of other *men of broad vision and deep experience who have seen science and religion as twin sisters which are effectively coöperating in leading the world on to better things.*

My argument thus far has been merely this, that there can be no conflict between science and religion if the greatest minds in the two fields, the minds to which we look for our definitions of what both science and religion are, have not only not seen such a conflict but have clearly seen and clearly stated that there is none.

But now let me go to my second obvious fact and show why in the nature of things

there can be no conflict. This appears at once as soon as one attempts to define for himself what is the place of science and what the place of religion in human life. *The purpose of science is to develop without prejudice or preconception of any kind a knowledge of the facts, the laws, and the processes of nature. The even more important task of religion, on the other hand, is to develop the consciences, the ideals, and the aspirations of mankind.*

The definition of science I think all will agree with. The definition of religion is in essence that embodied in the teachings of Jesus, who, unlike many of his followers of narrower vision, did not concern himself at all with creeds, but centered his whole teaching about a life of service and the spread of the spirit of love. It is of course true that the scientific and the religious sides of life often come into contact and mutually support each other. Science without religion obviously may become a curse, rather than a blessing to mankind, but science dominated by the spirit of religion is the key to progress and the hope of the future. On the other hand, history has shown that religion without science breeds dogmatism, bigotry, persecution, religious wars, and all the other disasters which in the past have been heaped upon mankind in the name of religion, disasters

which have been so fatal to organized religion itself that at certain times and in certain countries the finest characters and the most essentially religious men have been found outside the church. In some countries that is the situation today, and *wherever this is true it is because the essence of religion has been lost sight of, buried under theologies and other external trappings which correspond exactly to the "mint, the anise, and the cummin" of Jesus' day.* If anyone wishes to see what disaster these excrescences can bring upon the cause of real religion let him read the history of the church in Asia Minor for the first six centuries and see for himself what sects and schisms and senseless quarrels over the nature of the person of Jesus can do in the way of sucking the life-blood out of the spirit of his teachings and out of the effectiveness of the organization which was started for the sole purpose of spreading that spirit.

Yet in America, at least, it is not primarily those inside the church who thus misinterpret and misunderstand it, though we must sorrowfully admit that such a group does exist there. It is, however, for the most part the outsiders, the critics who have never seen the inside of church walls, and many of whom know so little about the church in America as to actually believe that Christianity is to be identified

with medieval theology, when the fact is so obvious that he who runs may read, that all that is vital in Christianity has remained altogether untouched by the most complete revolutions in theology, such as have gone on, for example, during the past hundred years. Many of us were brought up under creeds and theologies which have now completely passed on, as such things will continue to do as the world progresses, and yet, as we look back, we see that the essential thing which the churches of our childhood were doing for us and for our neighbors then is precisely what they are doing now, namely, stimulating us to right conduct, as each of us sees it, inspiring us to *do as we know* we ought to do, developing our ideals and our aspirations. There is a very simple and a very scientific way of finding out for yourself what is the heart and center of the Christian religion, the fundamental and vital thing which it stands for in human society, and that is to get far enough back so that details are lost sight of and then to observe what is the element which is common to all Christian churches in the United States. He who does that will see at once that *it is the life and the teachings of Jesus which constitute all that is essential to Christianity, that the spread of his spirit of unselfishness, of his idealism, and of his belief*

in the brotherhood of man and the fatherhood of God is the great purpose of the Christian religion. In other words, that religion exists, as stated above, for the sake of developing the consciences, the ideals, and the aspirations of mankind.

My third obvious fact is that *both science and religion have reached their present status through a process of development from the crudest beginnings.* This will be universally recognized in the case of science, and in the case of religion the most superficial study of history shows that this is true. The religious ideals and practices of the American Indians and of all other primitive tribes, with their totem-poles and incantations, have obviously been of the most primitive type. The ideas of duty, of responsibility, have always been involved in these religions, but the motives of right conduct, as primitive man conceived it, have been, from our present point of view, of the most unenlightened and even unworthy sort.

But is it not altogether obvious that religion cannot possibly rise higher than the stage of development of the people of whose ideals it is the expression? Nothing could show that process of development better than the Bible itself, for the early books of the Old Testament reveal the conception of God, character-

istic indeed of the age, but not at all satisfying to us, for it was a God who was indeed benevolent and just toward his own chosen people, but vindictive and cruel and utterly regardless of the welfare of those outside this chosen group. This imperfect conception is developed and refined through the history of the Jews as portrayed in the Bible until it culminates in the all-embracing love and fatherhood preached by Jesus. He who would deny this developmental process going on in both science and religion and clearly revealed in all the records of the past which we have, must shut his eyes to the indisputable facts as they are presented in all history, including sacred history.

To me it has always been of the utmost interest and profit, especially when I was disposed to judge severely great religious leaders of the past, like Paul or Moses, to try to conceive myself living in their surroundings, with their lack of scientific knowledge, interpreting life from the limited point of view which they had, formulating rules of conduct relating, for example, to matters of hygiene, such as those dealt with in Deuteronomy, trying to interpret mysterious phenomena of nature like eclipses, the possession of evil spirits, etc., and when I do this my wonder always is that these men saw as

clearly as they did, and succeeded as well as they did in separating the fundamental from the incidental. Difficult as it is to judge the great leaders of the past by their standards rather than by ours, it is imperative that we do so if we are to form any just appreciation of them and of their contributions to the development of the race. Indeed, this is the essence of the whole problem. Once get this point of view and you will never think of asking whether Genesis is to be taken as a modern text-book of *science.* It was written long before there was any such thing as science. It is of the utmost importance from every point of view to realize that the Bible itself makes no claims whatever of *scientific* correctness or, for that matter, of verbal inspiration. It is rather the record of the *religious* experiences and development of a great race.

My fourth obvious fact is that *every one who reflects at all believes in one way or another in God.* From my point of view, the word atheism is generally used most carelessly, unscientifically, and unintelligently, for it is to me unthinkable that a real atheist should exist at all. I may not, indeed, believe in the conception of deity possessed by the Congo negro who pounds the tom-tom to drive away the god whose presence and influence he fears;

and it is certain also that no modern religious leader believes in the god who has the attributes which Moses, Joshua and the Judges ascribe to their deity. But it seems to me as obvious as breathing that every man who is sufficiently in his senses to recognize his own inability to comprehend the problem of existence, to understand whence he himself came and whither he is going, must in the very admission of that ignorance and finiteness recognize the existence of a Something, a Power, a Being in whom and because of whom he himself "lives and moves and has his being." *That Power, that Something, that Existence, we call God.* Primitive man, of course, had anthropomorphic conceptions of that being. He was not able to think of a god who was very different from himself. His god became angered and had to be appeased, he was jealous and vindictive and moody; but man's conceptions have widened with the process of the suns, and as he has grown up he has slowly been putting away childish things.

I am not much concerned as to whether I agree precisely with you in my conception or not, for "can men with thinking find out God?" Both your conception and mine must in the nature of the case be vague and indefinite. Least of all am I disposed to

quarrel with the man who spiritualizes nature and says that God is to him the Soul of the universe, for spirit, personality, and all these abstract conceptions which go with it, like love, duty, and beauty, *exist* for you and for me just as much as do iron, wood and water. They are in every way as real for us as are the physical things which we handle. No man, therefore, can picture nature as devoid of these attributes which are a part of your experience and mine, and which you and I *know* are in nature. If you, then, in your conception identify God with nature, you must perforce attribute to him *consciousness* and *personality*, or better, *superconsciousness* and *superpersonality*. You cannot possibly synthesize nature and leave out its most outstanding attributes. Nor can you get these *potentialities* out of nature, no matter how far back you go in time. In other words, materialism, as commonly understood, is an altogether absurd and an utterly irrational philosophy, and is indeed so regarded by most thoughtful men.

Without attempting, then, to go further in defining what in the nature of the case is undefinable, let me reassert my conviction that although you may not believe in some particular conception of God which I may try to give expression to, and although it is unques-

tionably true that many of our conceptions are sometimes childishly anthropomorphic, every one who is sufficiently in possession of his faculties to recognize his own inability to comprehend the problem of existence bows his head in the presence of the Nature, if you will, the God, I prefer to say, who is behind it all and whose attributes are partially revealed to us in it all, so that it pains me as much as it did Kelvin "to hear crudely atheistic views expressed by men who have never known the deeper side of existence." Let me then henceforth use the word God to describe *that which is behind the mystery of existence and that which gives meaning to it.* I think you will not misunderstand me, then, when I say that I have never known a thinking man who did not believe in God.

My fifth obvious fact is *that there have been two great influences in the history of the world which have made goodness the outstanding characteristic in the conception of God.* The first influence was Jesus of Nazareth; the second influence has been the growth of modern science, and particularly the growth of the theory of evolution. All religions, including Christianity, have impersonated the spirit of evil and the spirit of good, and in many instances the former has been given the controlling influence. All of us see much

in life which tends to make us pessimists. The good does not always prevail. Righteousness does not always triumph. What is the meaning of existence? Is it worth while? Are we going anywhere? Jesus and modern science have both answered that question in the affirmative — Jesus took it as his mission in life to preach *the news of the goodness of God.* He came in an age which was profoundly ignorant of modern science. He used the terms, in dealing with disease and evil, which were appropriate to his day, the only terms which his audiences could have understood, but he saw a God who was caring for every sparrow and who was working out through love a world planned for the happiness and well being of all creatures. Similarly science in the formulation of the theory of evolution has seen the world developing through countless ages higher and higher qualities, moving on to better and better things. It pictures God, however you may conceive him, as essentially good, as providing a reason for existence and a motive for making the most of existence, in that we may be a part of the great plan of world progress. No more sublime conception of God has ever been presented to the mind of man than that which is furnished by science when it represents him as revealing himself through count-

less ages in the development of the earth as an abode for man and in the age-long inbreathing of life into its constituent matter, culminating in man with his spiritual nature and all his godlike powers.

But let me go a step further. Science in bringing to light the now generally admitted, though not as yet obvious and undisputed fact, that this is not a world in which things happen by caprice, but a world governed throughout by law, has presented the most powerful motive to man for goodness which has ever been urged upon him, more powerful even than any which Jesus found. That "whatsoever a man soweth that shall he also reap" is no longer merely a biblical text; it is a truth which has been burned into the consciousness of mankind by the last hundred years of the study of physics, chemistry and biology. Science, then, not only teaches that God is good, but it furnishes man with the most powerful of motives to fit in with the scheme of goodness which God has provided in nature. It teaches him not only that disease breeds disease, but also, by inference at least, that hate breeds hate, that dishonesty breeds dishonesty, that the wages of sin is death, and on the other hand that love begets love. *It teaches him that the moral laws and the physical laws alike are all*

laws of nature, and that violations of either of them lead to disaster and to misery.

In closing this brief statement of the faith of the scientist, let me present a situation and a question. In the spring of 1912 the great ship *Titanic* had collided with an iceberg and was doomed. She was about to sink. The lifeboats were insufficient. The cry went up, "The women first!" The men stepped back. The boats were loaded and the men sank with the ship. You call it an heroic act. Why did they do it? Perhaps you answer, because it was the law of the sea and the men preferred to die rather than to live after having broken that law. Then take a simpler case, for I want a more fundamental answer. Two men were clinging after the wreck to a floating piece of timber. It would not support them both. One of them voluntarily let go and sank. Heroisms of just this sort happened thousands of times during the war. *Men threw away their lives for a cause.* Such events happen every day in times of peace. Why do they happen? Because men and women prefer to die rather than to live in the consciousness of having played the coward, of having failed to play their part worthily *in the great scheme of things.* It is true that not all men are like that, but I am optimist enough to think that

most men are. But now come back to the question, Why are most men like that? Simply because *most men believe that there is such a world scheme; that they are a part of it, that their deaths are going to contribute to its development, in short, because most men believe in God.* This is the obvious inference from the fact that men are willing to die for a cause. They may not know whether there is personal immortality for them or not, but they *do know with absolute certainty that they live on in memory and in influence;* many of them, too, have faith to believe that they live on in consciousness, but in either case they are a part of a plan of development *which gives meaning to life.* In other words, men who have the stuff in them which makes heroes all believe in God, in " a power in the world which makes for righteousness." Without that belief there is no motive for heroism or for self-sacrifices of any sort, nor any such thing as " the development of the consciences, the ideals, and the aspirations of mankind," which I said above, was the task of religion, for there is then no basis for ideals or for aspirations. This is why Kelvin said that " belief in God is the foundation of all religion."

If there be a man who does not believe, either through the promptings of his religious

faith or through the objective evidence which the evolutionary history of the world offers, in a progressive revelation of God to man, if there be a man who in neither of these two ways has come to feel that there is a meaning to and a purpose for existence, if there be such thorough-going pessimism in this world, then may I and mine be kept as far as possible from contact with it. If the beauty, the meaning and the purpose of this life as revealed by both science and religion are all a dream, then let me dream on forever!

IV

Science and Society[1]

I PROPOSE in this paper to compare very briefly the problems of the college graduate of my own time thirty-two years ago and those of the present, and then to point out what seem to me to be the most vital elements which must enter into the solution of the problems which today's graduating class will be called upon to face.

I have a very vivid picture of one of America's most constructive statesmen, Senator John Sherman, addressing my own class upon its graduation, and wishing with all his soul that he might be in our shoes. " My generation," said he (and his constructive work covered the fifty years from 1845 to 1895) " has had for its great task the preservation of the Union, the assuring to posterity of one unified representative government extending over the whole vast area embraced within the limits of our states and territories, the problem — new in the world's history — of creating the conditions which make it pos-

[1] An address given at the Commencement of Stanford University, June 18, 1923.

sible to try out democracy on a huge scale. That problem we have solved at an awful expense of money and of human lives. The war for the preservation of the Union is passed, and the process of recovery and reconstruction has been in the main completed. Your problem, young graduates, is to show how well, during the next half-century, you can make that kind of government work in a country three thousand miles one way by two thousand the other."

The half-century since 1891 is now two-thirds past, and if it were fair to shut our eyes to the rest of the world and to take the present situation in the United States as an index of how well we have carried out that task, my generation in America might perhaps look back with a certain complacency upon what it has done so far. Certainly, gauged by the standard of the material prosperity of the average citizen alone, I suppose that it will be generally agreed that in this June, 1923, the United States finds itself better off than any country has ever been at any time in the world's history — considerably better off than it was itself in 1891. Wages have more than doubled since that year, and costs have not yet doubled. The condition of the man at the bottom, whether you consider that man to be the unskilled laborer or the young

Ph.D. seeking a job, is better now than it was then, and it is immensely better than it has ever been in any preceding period of the world's history. In 1896, after a four-year college course, three years of work for the Ph.D. degree, and a further year in Germany, I myself obtained a position in physics in the University of Chicago at $800. Today, under the same circumstances, I might hope to receive from $1,800 to $3,000.

Our intellectual and cultural life has made much progress, too. In 1891 there was very little science in the United States. My friends called me very uncomplimentary names for going in for physics — " the deadest imaginable of subjects." They themselves were going in for that fascinating, and at that time new, subject of sociology. Since that time the advances in that same dead physics may be said, without a display of too much enthusiasm, to have thrilled the world, while the successes of sociology are more problematical. Physics has opened the eyes of mankind so that it can now see in very truth new worlds — a marvelous world of electrons, already quite well explored, which underlies our former world of atoms and molecules, a world of quanta, not yet well understood, which lies perhaps behind the ether. And our own country, too, has had a reasonable

share in this progress. Also the possibilities that can be seen ahead for further advance, both in knowledge and in physical well-being are exceedingly alluring if only stable conditions of society can be maintained so that science can have the opportunity to work out these possibilities.

This amazing progress in science has been reflected in industry, too. Since 1891 has come the internal combustion engine which now gives the humblest laborer a car, the " movie " giving him inexpensive, though as yet perhaps not always wholesome, recreation, the amplifier and the wireless, furnishing the world with a huge nervous system which transmits intelligence practically instantaneously throughout its whole giant frame, the airplane, in which man outsoars the eagle and outspeeds the swift, the X-ray with which he discovers the hidden sources of disease in his body, and antitoxins and antiseptics with which he has already banished forever certain of mankind's most awful plagues.

The discoveries which I myself have seen since my graduation transcend, I think, in both number and in fundamental importance all those which the preceding two hundred years brought forth, and these latter far transcend all those of the preceding five thousand years. Such is the acceleration at which the

processes of evolution in human affairs are now going on, — a fact tremendously stimulating or terribly depressing according as one has great faith in man or little.

All these things might have been included in the vision which John Sherman had when he longed to be in our shoes so as to help work out the problems which he saw ahead in a land at peace, prospering under stable republican government and working out its own destiny for the enlightenment, and later, perhaps, for the emulation of other nations not yet free from the domination of Cæsars. But what Sherman did not see was that through a vastly more bloody and desperate war than any which his generation had known or even dreamed of, not alone we, the inhabitants of the United States, should be faced in 1923 with the problem of making democracy work on a huge scale, but with us almost every important nation on earth. This problem has now become not merely a national but a world problem — and that, too, before the world was ready for it.

But we cannot now go back. The increase in the efficiency of the instruments of destruction has for fifty years been making it harder and harder for any autocrat or oligarchy which gets into control of the machinery of government to be dislodged. Revolution

against tyranny cannot occur in the future as easily as in the past. Russia today, under as fateful a despotism as ever existed anywhere, is a living proof of the disasters which may come to a country which loses self-government, which lets any privileged class whatever, whether represented by a so-called communist like Trotsky, or a God-ordained kaiser like Wilhelm II entrench itself in power. With revolution, then, increasingly difficult because of the growth and application of modern science I can see no hope of progress save as society adopts a form of government which permits of progress by *evolution* instead of by revolution, which makes possible the peaceful and gradual replacement of men and policies by new men and new policies when rulers lose their sense of proportion, as men in power are likely to do, and when policies have ceased to be productive of social results. *One of the greatest contributions of science to life is the discovery that progress is in general made by the evolutionary process.* Einstein does not replace Newton; he merely supplements him. *There are no revolutions in science.* In so far as Newtonian mechanics was a body of experimental facts it is eternally true. The whole of Newton is incorporated in Einstein. *Let the revolutionary reformer ponder well that fact.*

The supreme question which the present generation faces is, then, Can we make democracy work, not merely for America, but for the world? *Can we replace bullets by ballots?* That question is being asked more searchingly and more fearfully today than it was in 1891. *If an affirmative answer is found at all it will be because the nations of the earth, including our own, learn to take a more rational, a more objective, a more scientific attitude toward life and all its problems than any of them have as yet learned to take.* Some wag has said that the anti-evolutionist is opposed to evolution because it never did very much for him. I wish to take that witticism altogether seriously. It is literally true that a good many individuals are still *in the jungle* so far as their method of meeting life's problems, so far as the mainsprings of their conduct are concerned.

For in the jungle ignorance and prejudice and impulse and emotion *must* determine conduct, and *so long as that is the case none other save the law of the jungle is possible.* Man himself is just now emerging from the jungle. It was only a few hundred years ago that he began to try to use the experimental and the objective method, to try to set aside all his prejudices and his preconceptions, to suspend his judgment until he had all the facts before

him, to spare no pains to first see all sides of the situation and then to let his reason and his intelligence, instead of his passion and his prejudice, control his decisions. That is called the scientific method. Why? Not because it is applied only in the study of science, but because it has had its most striking development in the sciences, and because it finds its finest application today, though not its only one, in the analytical subjects of mathematics, physics, and chemistry. It is because of that method that these sciences have very recently made the astounding strides referred to a moment ago. It is because of it and what it has done already that scientists dare to hope that the law of the jungle can ultimately be displaced by the law of reason, not only in our domestic affairs but in our international ones as well. It is because of it that scientists in general believe that human life may be indefinitely enriched and human happiness enormously multiplied.

But how far are we from the application of that method now, even in our so-called enlightened United States? Let a few illustrations answer. A few weeks ago the daily press reported that the New York Legislature had passed a bill requiring that the history of the revolutionary period be taught in the New York schools so as to develop patriotism.

The only possible interpretation of that act was that the legislature desired the facts of the revolution to be distorted to suit the prejudices of dwellers in New York. It is fortunate, indeed, that this was the same legislature that has just passed a bill which, whatever its purely legal and technical status, is yet deliberately *aimed at* the nullification within New York State of the present constitution of the United States, since otherwise there would be two such legislatures instead of only one in this country. And yet New York thinks that it is representative at least of the average state of evolution and of intelligence of the country. Let us hope that it is mistaken!

My second illustration, however, is not taken from New York. I recently asked a prominent school-book publisher if it would be possible to begin a slow process of eliminating the misunderstandings which lead to war between peoples by inducing publishers of school histories in all countries to submit their proposed school books to three or four international historians of world repute, who would endorse them, if they were able to do so, by the statement that these histories pictured essentially correctly the portions of the field of history with which they dealt. His reply was, " No. It is not yet possible to take such

a step in the United States, for the reason that school boards do not yet in this country want history to be taught as it happened. They want something to be called history which pleases their pride and appeals to their prejudices, and I know it because we are ourselves just having our histories attacked in the State of Washington on the ground, not that they are incorrect but that they are unpatriotic." And this sort of thing is happening to publishers all over the United States. This means that we are doing in our America today precisely what the whole world condemned Germany for doing in all the years preceding 1914, namely, *teaching nationalism in preference to truth.*

The American newspaper which claims to have the largest circulation of any newspaper in the world displays as its motto the words of Stephen Decatur completely inexcusable, at least as they are usually understood, " Our country! May she always be right, but our country right or wrong." It was in very fact the international hates and misunderstandings caused by just that sort of teaching which brought on the great war. And yet there are a dozen American newspapers which are sedulously spreading not merely anti-British but anti-international propaganda of every description.

A British visitor who has traveled and lived in this country recently told me that if his analysis were correct the United States was more likely to start another war than was any nation of Europe. But if another such war as the last is started, I, for one, fear that the world may bid good-bye to civilization. I am far from being a pessimist, but the history of central Asia, once at the center of the earth's civilization, and again, the very recent history of Russia, both show that it is possible to destroy civilization completely in a very few years of time. *Let those who deliberately set to work by distortion and untruth, by misrepresentation and cynical mistrust of motives, to stir up class hates and class prejudices in America, reflect well upon these things.* Some of them do it from base motives, because the mob has votes or pennies; others have good enough intentions but neither the intelligence nor the training to catch the scientific spirit and to be able, or even to try, to distinguish truth from falsehood. Well-meaning men without poise or any sort of scientific discrimination, and highly trained and able men without conscience are about equally grave dangers to the wholesome development of human society.

Another glaring example. Look at the storm of protest raised in the United States

Senate when Mr. Harding proposed that we begin to try to establish a machinery for settling judicially our international difficulties by joining the Hague court of international justice, a body organized largely through the genius of our own Mr. Elihu Root and advocated in essence by both political parties for twenty years and then ask yourself whether that protest was dictated by ignorance and prejudice or by intelligence and the scientific spirit.

But I do not need to go to Washington, to Chicago, or to New York, nor even to the field of politics for illustrations. We have not, indeed, passed anti-evolution laws as yet in California, but we have many people even here who hasten to condemn evolution without having the remotest conception of what it is that they are condemning, nor the slightest interest in an objective study *of the evidence in the case which is all that "the teaching of evolution" means*, men whose decisions have been formed, as are all decisions in the jungle, by instinct, by impulse, by inherited loves and hates, instead of by reason. Such people may be amiable and lovable, just as is any house dog, but they are a menace to democracy and to civilization because ignorance and the designing men who fatten upon it control their votes and their

influence. The churches are often charged by their critics with having more than their share of this type of jungle dwellers, but my own observation is that there are almost as many among the leaders of the churches who have caught the scientific spirit as there are among the so-called scientists themselves, and many more who have caught what is even more essential to progress, the altruistic spirit. Medical science certainly is full of the jungle dwellers, as is shown by the existence of such a scientific anomaly as sects in medicine. *For science is an objective study of the facts of nature.* It uses any and all hypotheses which assist in correlating these facts, and its many hypotheses have had varying degrees of success in making such correlations, but science never commits itself as a matter of faith to any of them, not even to evolution. When it does so it ceases to be science.

But what, now, is the remedy? Is there any hope for the improvement of the situation and the elimination of the dangers which threaten the permanence and success of our modern society inside our commonwealth and outside of it? I have no nostrums to propose. The longer one lives the less confidence does he have in any universal formula. The situation itself which I have portrayed suggests the only solution which there can

be, namely, the slow growth of a larger degree of *both public intelligence and public conscience than we now have. Intelligence enables one to know better what he ought to do, while conscience keeps him doing as he knows he ought.* In America the school has concerned itself primarily with the first field, the church with the second. Which will play the larger rôle in getting us out of the jungle I will not attempt to say, but it appears to me fairly obvious that without both of them human society is headed for the rocks. But science, imbued with the spirit of service, which is the essence of religion, and religion guided by the intelligence, the intellectual honesty, the objectiveness, and the effectiveness which is characteristic of the spirit of science, can between them, without a shadow of a doubt, in view of the rate at which discoveries are now being made and at which changes are being brought about, transform this world in a generation. If that transformation actually gets very far in your lifetime, members of the class of 1923, it will be because of the following sorts of influences:

First, it will be because you, graduates, and others of your opportunities, act as centers for the growth in the communities in which you live of both the scientific spirit and the altruistic spirit, and a relatively few such

centers can accomplish wonders, for most men follow while but few men lead. It will be because you do not sit idly and thoughtlessly by, expecting that leadership to come from New York or Chicago or other great centers of population. Athens, with its hundred thousand Greeks, did more to shape the development of the race than any city of fifty times its population has ever done, and an insignificant village in Galilee did more than Athens. The only way in which public sentiment, the sovereign power in a democracy, can be developed is by having hundreds and thousands of such centers as we may ourselves create in the communities in which we live. There is nothing new nor spectacular about that remedy any more than there is about any of the processes of growth; but these are, after all, the processes by which most of the progress of this world comes about.

Secondly, I think that people of intelligence will soon take steps to so reorganize the teaching of science in the public schools as to give a larger fraction of the pupils who go through our high schools and colleges more training, particularly in the mathematical and physical sciences, for from my point of view there is no training in objective, analytical thinking, nor in honesty and soundness of judgment, which is comparable to the training furnished

by these sciences. I know of no training for life which is equal to it, whether one is to be an engineer, lawyer, business man, or preacher. It is an exceedingly wholesome thing to work at some time in one's life in a field in which *the distinction between right and wrong, between loose and correct thinking, cannot be obliterated or escaped*; to learn that there are eternal physical laws and presumably also eternal æsthetic, moral, and social laws in conformity with which one must proceed if he is to arrive at correct results; to learn, too, that four-fifths of all the experiments which we make in our physical laboratories in the hope of developing new relations, establishing new laws, or opening up new avenues of progress, are found to be directed along wrong lines and have to be abandoned. There is no reason to suppose that any larger percentage of the efforts which are made toward social, political, or educational reform are in the actual direction of progress. With a better realization of these facts we should have less worship of the new *merely because it is new*, fewer cubists in art, in literature, in education, in politics, in social reform. A well-known resident of Southern California who had a fine training in physics and mathematics but has spent his later life as a farmer and fruit grower said to me the other day,

" I do not use my science much on my ranch. I guess and blindly follow tradition almost as much as my neighbors, but I know *when I don't know* and they do not. That is worth all my education cost me." If such a change in our public school curriculum as I am suggesting is brought about at all, it is going to be done, I think, through a reorganization of the required group of studies rather than by important changes in methods of instruction in the individual sciences. This is primarily a matter for the attention of the superintendents and principals of our public schools.

In the third place, public-spirited men are going to see more and more that the support in a large way of scientific research is an investment which brings the largest returns of satisfaction to themselves and of progress to mankind which can be made at all. It is my own belief that no efforts toward social readjustments or toward the redistribution of wealth, such as so many well-meaning people are urging in a thousand different ways, have one-tenth part as good a chance of contributing to human well-being as have the efforts of the physicists, the chemists, the biologists, and the engineers toward the better understanding and the better control of nature. The distribution of wealth can,

of course, be improved, and I welcome every constructive and sane effort toward its improvement, but the results which can be accomplished for the well-being of mankind by efforts in this direction seem to me to be utterly trivial in comparison with those which may be brought about by physical and biological research. An eminent and progressive economist told me lately that no sort of redistribution of the wealth now available could possibly add more than ten per cent to the income of the average man, and probably much less than that. To replace for the toiler a dollar meal by a dollar and ten cent meal is scarcely my idea of the millennium.

In the fourth place — and this is in my opinion most important of all — *the spirit of religion and the spirit of science are going to join hands*, because the leaders of both religion and of science are coming increasingly to see life as a whole instead of from the pathetically narrow and unscientific point of view from which some in both fields have in the past looked upon it. This is one of the places at which you, young graduates, have your greatest opportunity to exert a very large influence upon your generation.

I should like, in closing, to call two recent events to the attention of any man who is wondering whether after all there is any

progress, whether mankind gets farther away from the method of the jungle, and develops any more of the spirit of science, or of the spirit of service than he had in the past. Both of these events seem small, but I think they are pregnant with meaning and with encouragement for the man who has begun to wonder whether human society can ever really catch both the *scientific spirit and the altruistic spirit* and realize the immense possibilities which are before it when it does.

My first event is in the field of medical education. I am informed by my medical friends that the medical fraternity has actually educated itself up to the point where allopaths and homœpaths have got together, to abolish, so far as they themselves are concerned, sectarian schools of medicine. The last of these particular sectarian schools, so I am told, has gone, having been simply and rationally combined into schools which teach merely *medical science* as it is known today. Truly "the thoughts of men *are* widened with the process of the suns!"

The second ground for encouragement is found in the following fact: A statement upon the relations of science and religion was recently drawn up, which Bishop Johnson of Los Angeles characterized as a "thoroughly pious statement." It asserted that religion

and science were not only not antagonistic, but that both were necessary to the progress and the happiness of mankind. Further, this statement definitely recognized God, and it definitely assigned to religion an even more important place in human life than to science. On the other hand, it called for the recognition by all the signers of the scientific method. *Fifteen-sixteenths of all the scientists to whom that statement was submitted signed it at once without a question as the statement of their belief*, and these men were chosen, let it be remembered, solely because of their outstanding character as scientists and without any knowledge of their religious views. Three-fourths of all the men of affairs approached signed and none expressed dissent, a few, however, preferring for political reasons not to join in the statement. Two-thirds of the religious leaders who were interrogated signed, most of whom were of the more conservative groups. The response of the scientists is particularly significant and possibly has some bearing upon the breadth of view developed by scientific training. After this showing who is he who is asserting that science is materialistic and irreligious? There are a few scientists, it is true, but only a few, who forget the scientific method when they touch the field of religion and scoff at it without

knowing anything about it, and these men, too, have their exact counterparts, perhaps in slightly larger numbers, in the field of religion where there is, I regret to say, a group of blind leaders of the blind, men who still follow the method of the jungle and are still imbued with its spirit of prejudice, preconception and intolerance. Yet there is here the best of evidence that the leadership in both science and religion is in the main imbued with both the spirit of intellectual honesty and objectiveness which is characteristic of science, and the spirit of altruism and service which is the glory of religion. *This combination is the only nostrum which there is for human ills, the only hope for a paradise on earth, and each of us has the opportunity to do his bit toward bringing it about.*

The purpose of the following statement is to assist in correcting two erroneous impressions which seem to be current among certain groups of persons. The first is that religion today stands for medieval theology; the second, that science is materialistic and irreligious.

A JOINT STATEMENT UPON THE RELATIONS OF SCIENCE AND RELIGION[1]

By a Group of Scientists, Religious Leaders, and Men of Affairs.

We, the undersigned, deeply regret that in recent controversies there has been a tendency to present science and religion as irreconcilable and antagonistic domains of thought, for in fact they meet distinct human needs, and in the rounding out of human life they supplement rather than displace or oppose each other.

The purpose of science is to develop, without prejudice or preconception of any kind, a knowledge of the facts, the laws, and the processes of nature. The even more important task of religion, on the other hand, is to develop the consciences, the ideals, and the aspirations of mankind. Each of these two activities represents a deep and vital function of the soul

[1] This is the statement referred to in the preceding address and published widely in the press of the United States in June, 1923.

of man, and both are necessary for the life, the progress, and the happiness of the human race.

It is a sublime conception of God which is furnished by science, and one wholly consonant with the highest ideals of religion, when it represents him as revealing himself through countless ages in the development of the earth as an abode for man and in the age-long inbreathing of life into its constituent matter, culminating in man with his spiritual nature and all his God-like powers.

RELIGIOUS LEADERS

Bishop William Lawrence, Episcopalian, Bishop of Massachusetts, Boston.
Bishop William Thomas Manning, Episcopalian, Bishop's House, Cathedral Heights, New York City.
Bishop Joseph H. Johnson, Episcopalian, Bishop of Los Angeles, California.
Dr. Henry van Dyke, Presbyterian, Preacher and Poet, Princeton, New Jersey.
Dr. James I. Vance, Presbyterian, First Presbyterian Church, Nashville, Tennessee.
Dr. John D. Davis, Presbyterian, Professor of Old Testament Literature, Princeton Theological Seminary, Princeton, New Jersey.
President James Gore King McClure, Presbyterian, McCormick Theological Seminary, Chicago, Illinois.
President Clarence A. Barbour, Baptist, Rochester Theological Seminary, Rochester, New York.
President Ernest D. Burton, Baptist Theologian, President of University of Chicago, Illinois.
President William Louis Poteat, Baptist, Wake Forest College, Wake Forest, North Carolina.

President Henry Churchill King, Congregationalist, Oberlin Graduate School of Theology, Oberlin, Ohio.
Dr. Robert E. Brown, Congregationalist, Second Congregational Church, Waterbury, Connecticut.
Bishop Francis John McConnell, Methodist, Pittsburgh, Pennsylvania.
Dr. Merle N. Smith, Methodist, First Methodist Church, Pasadena, California.
Dr. Peter Ainslie, Disciple, Christian Temple, Baltimore, Maryland.
Dr. Herbert L. Willett, Disciple Theologian, Associate Editor, *Christian Century*, Chicago, Illinois.

SCIENTISTS

Charles D. Walcott, Geologist, President of the National Academy of Sciences, President of the American Association for the Advancement of Science, and Head of the Smithsonian Institution of Washington.
Henry Fairfield Osborn, Paleontologist, President of the American Museum of Natural History, New York.
Edwin Grant Conklin, Zoologist, Head of the Department of Zoology, Princeton University.
James Rowland Angell, Psychologist, President of Yale University.
John Merle Coulter, Botanist, Head of the Department of Botany, University of Chicago.
Michael I. Pupin, Physicist and Engineer, Professor of Electromechanics and Director of Phœnix Research Laboratory, Columbia University.
William James Mayo, Surgeon, Mayo Foundation for Medical Education and Research, Rochester, Minnesota.
George David Birkhoff, Mathematician, Head of the Department of Mathematics, Harvard University, Cambridge, Massachusetts.
Arthur A. Noyes, Chemist, Director of the Gates Chemical Laboratory, California Institute of Technology, Pasadena, California.

William Wallace Campbell, Astronomer, Director of Lick Observatory and President-elect of the University of California.

John J. Carthy, Engineer, Vice-President in Charge of Research, American Telephone and Telegraph Company, New York.

Robert A. Millikan, Physicist, Director of Norman Bridge Laboratory of Physics, Pasadena, California.

William Henry Welch, Pathologist, Director of the School of Hygiene and Public Health, Johns Hopkins University, Baltimore.

John C. Merriam, Paleontologist, President of The Carnegie Institution of Washington.

Gano Dunn, Engineer, Chairman of the National Research Council, Washington, D. C.

MEN OF AFFAIRS

Herbert Hoover, Secretary of Commerce, Washington, D. C.

James John Davis, Secretary of Labor, Washington, D. C.

Elihu Root, ex-Secretary of State, New York City

David F. Houston, ex-Secretary of the Treasury, 195 Broadway, New York City.

Frank O. Lowden, ex-Governor of Illinois, Oregon, Illinois.

John Sharpe Williams, ex-United States Senator, Yazoo City, Mississippi.

Rear Admiral William S. Sims, Commander United States Naval Forces in European Waters during the World War, Newport, Rhode Island.

Harry Bates Thayer, President American Telephone and Telegraph Company, 195 Broadway, New York City.

Julius Kruttschnitt, Chairman of the Executive Committee, Southern Pacific Railway, 165 Broadway, New York City.

Frank Vanderlip, ex-President National City Bank of New York, Scarborough, N. Y.

Science and Life

Henry S. Pritchett, President Carnegie Corporation of New York.
William Allen White, Writer and Editor of Emporia *Gazette*, Emporia, Kansas.
Victor F. Lawson, Editor and Publisher of the Chicago *Daily News*.
John G. Shedd, ex-President of The Marshall Field Company, Chicago.

215
~~M654s~~
M621s
69-1842
Millikan, Robert Andrews
Science and life

215
M621s
69-1842
Millikan, Robert Andrews
AUTHOR
Science and life
TITLE

DATE DUE	BORROWER'S NAME

THE MASTER'S COLLEGE
POWELL LIBRARY
SANTA CLARITA, CA 91321

~~215~~
~~AP 4 S4 S~~

69-1842

11-15-34 (.25)

THE MASTER'S COLLEGE
215 M621s MAIN
Millikan, Robert Andrew/Science and life
3 3540 00001 7557